

Claims

1. Integrated blood treatment module comprising:

- a blood treatment device (1, 100) having:

- a housing (2) having a longitudinal axis (3);

- a first end-cap (4) closing a first end of the housing (2), the first end-cap having a blood inlet port (15, 104);

- a second end-cap closing (5) a second end of the housing (2);

- a pump hose (17) for a peristaltic pump, wherein the pump hose (17) has a first end (18) that is secured to the housing (2) and a second end (16) that is connected to the blood inlet port (15, 104) so that the pump hose (17) extends in a position that is complementary to the position of a race of the peristaltic pump; and

- a degassing device (30) connected to the second end-cap (5) having:

- a first chamber (31) having an inlet for receiving a liquid flowing into the second end-cap (5), and

- a second chamber (32) having an opening (33) closed by a hydrophobic membrane (34) and an outlet (35) for discharging the liquid,

wherein the first chamber (31) has a downstream portion that partially extends within the second chamber (32) and communicates therewith by a passageway (38), and the second chamber (32) has a downstream portion that extends below the passageway (38) and asymmetrically surrounds the downstream portion of the first chamber (31).

2. Integrated blood treatment module according to claim 1, further comprising a first pressure measurement chamber (7) that is secured to the blood treatment device (1) and is connected to the first end (18) of the pump hose (17), the first pressure measurement chamber (7) having a pressure measurement port (12) for connection to a pressure sensor, the pressure measurement port having a central axis that is parallel to a central axis of at least one access port (6) of the housing (2).

3. Integrated blood treatment module according to one of the claims 1 and 2, further comprising a second pressure measurement chamber (8) that is secured to

the blood treatment device (1) and is connected to the outlet port (35) of the blood degassing device (30), the second pressure measurement chamber (8) having a pressure measurement port (12) for connection to a pressure sensor, the pressure measurement port (12) having a central axis that is parallel to a central axis of at least one access port (6) of the housing (2).

4. Integrated blood treatment module according to one of the claims 1 to 3, further comprising a third pressure measurement chamber (9) that is secured to the blood treatment device (1) and is connected to the second end (16) of the pump hose (17), the third pressure measurement chamber (9) having a pressure measurement port (12) for connection to a pressure sensor, the pressure measurement port (12) having a central axis that is parallel to a central axis of at least one access port (6) of the housing (2).

5. Integrated blood treatment module according to claim 1, further comprising a support structure (60, 80, 90) having a plurality of conduits (64, 66, 68, 70, 71, 73, 75, 78, 82) defined therein, the blood treatment device (100) being secured to the support structure (60, 80, 90).

6. Integrated blood treatment module according to claim 5, wherein the support structure (60, 80, 90) comprises a first conduit (64) having a first end connected to a first access port (6) of the housing (2), and a second end comprised of an outlet nozzle (65) for a waste liquid.

7. Integrated blood treatment module according to one of the claims 5 and 6, wherein the support structure (60, 80, 90) comprises a second conduit (66) having a first end connected to a second access port (6) of the housing (2), and a second end comprised of an inlet nozzle (67) for a dialysis liquid.

8. Integrated blood treatment module according to one of the claims 5 to 7, wherein the support structure (60, 80, 90) comprises:

- a third conduit (68) having an inlet for connection to a blood withdrawal tube (69), and an outlet connected to the first end (18) of the pump hose (17); and

- a fourth conduit (70) having an inlet connected to the second end (16) of the pump hose (17), and an outlet connected to the blood inlet port (15) of the first end-cap (4).

- 5 9. Integrated blood treatment module according to claim 8, wherein the support structure (60, 80, 90) comprises a sixth conduit (73) having a first end connected to the fourth conduit (70) and a second end for connection to a pre-dilution infusion tube (74).
- 10 10. Integrated blood treatment module according to one of claims 8 and 9, further comprising a first pressure measurement chamber (7) defined within the support structure (60, 80, 90) and connected to the third conduit (68) for measuring a pressure upstream of the pump hose (17).
- 15 11. Integrated blood treatment module according to one of the claims 8 to 10, wherein the outlet of the third conduit (68) and the inlet of the fourth conduit (70) are arranged with respect to each other so that the pump hose (17) forms a loop that extends in a plane substantially parallel to the longitudinal axis (3) of the housing (2).
- 20 12. Integrated blood treatment module according to claim 11, wherein the outlet of the third conduit (68) is located between the two end-caps (4, 5) and the loop formed by the pump hose (17) extends laterally with respect to the housing (2) of the blood treatment device (100).
- 25 13. Integrated blood treatment module according to claim 11, wherein the outlet of the third conduit (68) is located along the longitudinal axis (3) of the housing (2) beyond the first end-cap (4), and the loop formed by the pump hose (17) is offset along the longitudinal axis (3) of the housing (2) with respect to the housing (2) of
- 30 the blood treatment device (100).
14. Integrated blood treatment module according to of the claims 8 to 10, wherein the outlet of the third conduit (68) and the inlet of the fourth conduit (70) are arranged with respect to each other so that the pump hose (17) forms a loop (17)

that extends in a plane inclined with respect to a plane substantially perpendicular to the longitudinal axis (3) of the housing (2).

15. Integrated blood treatment module according to one of the claims 5 to 14,
5 wherein the support structure (60, 80, 90) comprises a fifth conduit (71) having an inlet connected to the outlet port (35) of the blood degassing device (30), and an outlet for connection to a blood return tube (72).

16. Integrated blood treatment module according to claim 15, wherein the support
10 structure (60, 80, 90) comprises a seventh conduit (75) having a first end connected to the fifth conduit (71) and a second end for connection to a post-dilution infusion tube (76).

17. Integrated blood treatment module according to one of the claims 15 and 16,
15 further comprising a second pressure measurement chamber (8) defined within the support structure (60, 80, 90) and connected to the fifth conduit (71) for measuring a pressure downstream of the blood degassing device (30).

18. Integrated blood treatment module according to claims 10 and 17, wherein the
20 first pressure measurement chamber (7) has a port (12) for connection to a pressure sensor, the second pressure measurement chamber (8) has a port (12) for connection to a pressure sensor, and wherein the inlet nozzle (67), the outlet nozzle (65), the port (12) of the first pressure measuring chamber (7) and the port (12) of the second measuring chamber (8) have respective central axes that are
25 substantially parallel.

19. Integrated blood treatment module according to claim 18, wherein the
respective central axes of the inlet nozzle (67), of the outlet nozzle (65), of the port (12) of the first pressure measuring chamber (7) and of the port (12) of the second
30 measuring chamber (8) are substantially perpendicular to the longitudinal axis (3) of the housing (2).

20. Integrated blood treatment module according to one of the claims 1 to 19,
wherein the downstream portion of the second chamber (32) has a lateral wall (39)

that surrounds a longitudinal axis (37) of the degassing device (30) and a bottom wall (40) that is inclined with respect to a longitudinal axis (37) of the degassing device.

5 21. Integrated blood treatment module according to claim 20, wherein the downstream portion of the first chamber (31) has a lateral wall (36) that is concentric to the lateral wall (39) of the second chamber (32).

10 22. Integrated blood treatment module according to claim 21, wherein the lateral wall (36) of the downstream portion of the first chamber (31) and the lateral wall (39) of the downstream portion of the second chamber (32) are substantially cylindrical.

15 23. Integrated blood treatment module according to one of the claims 1 to 22, wherein the downstream portion of the first chamber (31) has a cross-section that is substantially the same as the cross-section of the passageway (38) between the first and the second chamber (32).

20 24. Integrated blood treatment module according to one of the claims 1 to 23, wherein the first chamber (31) comprises an upstream portion having a decreasing cross section.

25 25. Integrated blood treatment module according to one of the claims 1 to 24, wherein the second chamber (32) comprises an upstream portion extending above the passageway (38) that has a decreasing cross-section, with a larger cross-section that is substantially level with the passageway (38) and a smaller cross-section that is substantially level with the hydrophobic membrane (34).

30 26. Integrated blood treatment module according to claim 25, wherein the upstream portion of the second chamber (32) is substantially frusto-conical.

27. Integrated blood treatment module according to one of the claims 1 to 26, wherein the outlet port (35) opens in the downstream portion of the second chamber (32) at a location furthest to the passageway (38).

28. Integrated blood treatment module according to one of the claims 1 to 27, wherein the first chamber (31) of the degassing device (30) has a downstream portion having a cross-section selected with respect to a maximal flow rate of a liquid in the module so that the velocity of the liquid in the downstream portion of the first chamber (31) is less than a predetermined velocity.

29. Integrated blood treatment module according to claim 28, wherein the cross-section of the downstream portion of the first chamber (31) is selected with respect to a maximal flow rate of a liquid of about 500ml/min in the module so that the velocity of the liquid in the downstream portion of the first chamber (31) is less than about 3m/min.

30. Integrated blood treatment module according to one of the claims 1 to 29, wherein the cross-section of the second chamber (32) of the degassing device (30) at the level of the passageway (38) is selected so that the ratio of the velocity of a liquid within a downstream portion of the first chamber (31) to the velocity of the liquid within the second chamber (32) at the level of the passageway (38) is more than a determined value.

31. Integrated blood treatment module according to claim 31, wherein the cross-section of the second chamber (32) of the degassing device (30) at the level of the passageway (38) is selected so that the ratio of the velocity of the liquid within the downstream portion of the first chamber (31) to the velocity of the liquid within the second chamber (32) at the level of the passageway (38) is at least about 2.

32. Integrated blood treatment module according to one of the claims 1 to 31, wherein the downstream portion of the second chamber (32) forms an overflow for a fluid flowing from the first chamber (31) into the second chamber (32).

33. Integrated blood treatment module according to one of the claims 1 to 32, wherein the first chamber (31), the second chamber (32) and the passageway (38) therebetween are arranged with respect to each other so that a flow pattern of a

liquid flowing from the first chamber (31), through the second chamber (32) and to the outlet port (35) comprises a component that is tangential to the membrane.

5 34. Integrated blood treatment module according to claim 33, wherein the flow pattern of a liquid flowing from the first chamber (31), through the second chamber (32) and to the outlet port (35) comprises an umbrella like component.

10 35. Integrated blood treatment module according to one of the claims 1 to 34, wherein the first chamber (31), the second chamber (32) and the passageway (38) therebetween are arranged with respect to each other so that a flow of liquid flowing from the first chamber (31), through the second chamber (32) and to the outlet port (35) keeps gas bubbles in motion along an inner surface of the hydrophobic membrane (34).

15 36. Integrated blood treatment module according to any of the claims 1 to 35, further comprising a protective member (45, 49) for protecting the hydrophobic membrane (34) against external blows and for limiting the deformation of the hydrophobic membrane (34) when the pressure of the liquid within the degassing device exceeds a limit.

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37. Integrated blood treatment module according to one of the claims 1 to 36, wherein the hydrophobic membrane (34) is arranged in a plane substantially perpendicular to a longitudinal axis (37) of the degassing device (30).

25 38. Integrated blood treatment module according to one of the claims 1 to 36, wherein the blood treatment device (1, 100) is a hemodialyzer, a hemofilter or a plasmafilter.